DATE: **March 17, 2003**

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SUBJECT: **Diesel Engine Retrofit Cost Analysis**

As part of the NR 445 rule revision process, the WDNR made an effort to contact and obtain cost information from leading stationary diesel engine and retrofit technology manufacturers. The results and the process used to obtain the information are briefly described below.

Applicable Stationary Diesel PM Emission Control Technologies

Two primary strategies available to limit PM emissions from diesel engines are minimization of diesel fuel sulfur content and application of control technologies.

PM control technologies widely available for retrofit of stationary diesel engines include diesel particulate filters (DPF), diesel oxidation catalysts (DOC), and selective catalytic reduction (SCR). Each technology has varying effects on PM reductions depending upon engine size and use patterns, fuel sulfur level, control technology material composition, and engine maintenance techniques and systems. Additional PM control methods are available, and include technologies such as fuel borne catalysts (FBC), exhaust gas re-circulation (EGR), and advanced engine control systems, amongst others. These technologies can be combined in certain circumstances to further enhance PM emission reductions.

The WDNR undertook a survey of available PM control technology sources in an attempt to determine the emission reduction capabilities of various technologies. This preliminary research indicated that diesel particulate filters were the control mechanism of choice to reach the emission reductions proposed by the WDNR. The remainder of this analysis compares cost data for DPF technology versus typical stationary diesel engine purchase and operation and maintenance cost in an effort to get a better sense of the economic impacts of the proposed rule. Cost data for other available PM technologies are included as well for comparison purposes.

Diesel Engine Cost Research Process

The Department began the cost analysis by speaking with industry organizations in an effort to obtain individual company contacts. The Engine Manufacturers Association (EMA) and the Manufacturers of Emission Control Association (MECA) were initially consulted to obtain reliable contacts for major manufacturers of stationary diesel engines and retrofit technologies.

After phone numbers and e-mail addresses for major manufacturers were obtained, the Department phoned six major diesel engine manufacturers (Caterpillar, Cummins, Detroit Diesel, John Deere, Scania, and Deutz) in an effort to obtain information through an interview. Partially due to the holiday season, these efforts were largely unsuccessful. Follow-up e-mails containing a brief list of questions (See Appendix A) were sent to each manufacturer in early January. Response to these surveys has been minimal, although further submissions are expected.

Retrofit Technology Cost Research Process

A similar process was employed to obtain information from diesel engine retrofit technology manufacturers. Following acquisition of contact information from MECA, and other sources, two major independent diesel engine retrofit technology manufacturers (Engelhard, Johnson Matthey) were called to obtain cost data. Stationary diesel engine retrofit technology divisions within Caterpillar and Detroit Diesel were also contacted to obtain technology cost data. Again, due to the holiday season, telephone interview efforts were largely fruitless. A survey (See Appendix B) was sent to each of the manufacturers in an effort to obtain further information. The Department is still awaiting responses to this survey.

In addition to contacting technology manufacturers, the Department conducted Internet research in an effort to locate broad retrofit technology cost studies. As a result of this search, the Department found the MECA Independent Cost Survey for Emission Control Retrofit Technologies, which specifies various diesel retrofit technology costs by engine horsepower.[1] The MECA study was dated year 2000, so the WDNR attempted to determine if technology costs had changed significantly since that time. The Department e-mailed the technology manufacturer survey to MECA, but have yet to receive a response.

The Internet research conducted by the WDNR also revealed a large amount of diesel cost data on the California Air Resources Board (CARB) website. The information was spread among several websites. The WDNR attempted to obtain a summary of stationary diesel engine technology costs by contacting CARB. Although summary data is not available, information provided by CARB indicates that the technology cost data summarized below is reasonable.

Stationary Diesel Engine Retrofit Cost Findings

As a result of the efforts described above, the WDNR was able to obtain the following data[2]. The diesel engine and retrofit technology cost data summarized below is not all-encompassing, and only represents the information gathered from responses to the Department's list of questions (see Appendices A and B). As of the date of this memo, the department had received one response from diesel engine manufacturers (Caterpillar). Two sources of data (MECA and Caterpillar) were used in the technology cost tables. If information was unavailable, cells in the table were left blank.

Table 1: Stationary Diesel Engine Cost Data

Engine Size (hp)	Low Engine Purchase Cost ($)	High Engine Purchase Cost ($)	Engine O and M Cost ($/hr)	Low Engine Lifespan (hours)	High Engine Lifespan (hours)
100	7000	10000	0.89	6000	10000
250	15000	25000	2.22	6000	10000
500	32000	48000	4.48	8000	12000
750	60000	80000	6.84	8000	12000
1500	150000	180000	13.43	22500	22500

[1] The MECA diesel retrofit cost study is available at http://www.epa.gov/otaq/retrofit/retrocost.htm.

[2] The WDNR assembled data from interviews, survey responses, and other available resources. These sources were used to determine a likely range of values for each column of the tables.

Table 2: DPF Cost Data

Engine Size (hp)	Low Tech Purchase Cost ($)	High Tech Purchase Cost ($)	Tech O and M Cost ($/yr)	Tech Lifespan (years)
100	3000	4800	500	5
250	3000	5200	500	5
500	3000	5800	500	5
750	6300	6300	500	5
1500	6800	6800	500	5

Table 3: DOC Cost Data

Engine Size (hp)	Low Tech Purchase Cost ($)	High Tech Purchase Cost ($)	Tech O and M Cost ($/yr)	Tech Lifespan (years)
100	425	1450	0	life of engine
250	650	1700	0	life of engine
500	900	1850	0	life of engine
750	2000	2000	0	life of engine
1500	2500	2500	0	life of engine

Table 4: SCR Cost Data

Engine Size (hp)	Low Tech Purchase Cost ($)	High Tech Purchase Cost ($)	Tech O and M Cost ($/yr)	Tech Lifespan (years)
100	10000	40000		
250	10500	45000		
500	11000	50000		
750				
1500				

Table 5: DPF/LNC Combo Cost Data

Engine Size (hp)	Low Tech Purchase Cost ($)	High Tech Purchase Cost ($)	Tech O and M Cost ($/yr)	Tech Lifespan (years)
100	4000	6000		
250	6500	8500		
500	9000	11000		
750				
1500				

Table Notes

1. Low and High in the tables refer to the minimum and maximum values submitted by respondents for the column of interest. For example, Low Engine Purchase Cost for a 100-hp engine is 7000 dollars. This means that the lowest cost submitted by a respondent for a 100 hp diesel engine was 7000 dollars, while the highest cost was 10,000 dollars. This tells us that typical costs for 100 hp engines fall within 7,000 and 10,000 dollars depending upon the application.

2. O and M cost refers to Operations and Maintenance Cost. For the diesel engines themselves, O and M cost includes oil filters, fuel filters, air filters, routine maintenance, unscheduled repairs, and engine overhaul after useful life. O and M costs DO NOT include diesel fuel. For the particulate matter control technologies, O and M cost includes labor costs for periodically removing and cleaning the devices.

Appendix A:

Diesel Engine Manufacturer Interview Questions

Contact Company _____
Contact Name _____
Contact Phone Number _____
Date _____

1. Does your company sell non-mobile diesel engines? What are their typical applications?

2. What is a purchase cost range for a non-mobile diesel engine of the following sizes?

   100 hp
   250 hp
   500 hp
   750 hp
   1500 hp
   >1500 hp

3. What is the typical operation and maintenance cost for a non-mobile diesel engine of the following sizes? What would these operation and maintenance costs entail?

   100 hp
   250 hp
   500 hp
   750 hp
   1500 hp
   >1500 hp

4. For your company's new non-mobile diesel engines, what is the particulate matter emission rate in g/bhp*hr? What procedure did you follow to acquire this data?

   100 hp
   250 hp
   500 hp
   750 hp
   1500 hp
   >1500 hp

5. What is the average life span of your non-mobile diesel engines?

   100 hp
   250 hp
   500 hp
   750 hp
   1500 hp
   >1500 hp

6. Do you supply exhaust systems for your own engines, or does a third party?

Appendix B:

Diesel Retrofit Technology Manufacturer Interview Questions

Contact Company _____
Contact Name _____
Contact Phone Number _____
Date _____

1. What particulate matter emission reduction technologies do you offer for retrofit of non-mobile diesel engines?

2. What is the initial cost to retrofit different sized engines with the technologies you produce?

100 hp
250 hp
500 hp
750 hp
1500 hp

3. What are typical yearly operation and maintenance costs for your retrofit technologies by engine size?

100 hp
250 hp
500 hp
750 hp
1500 hp

4. What is the average warrantied life span for your technologies on different sized engines?
   - What is the average operational life span?

100 hp
250 hp
500 hp
750 hp
1500 hp

5. What is the particulate matter emission reduction potential of your retrofit technologies?
   - Exhaust emission rate in g/bhp*hr would be excellent, but % reduction will work.
   - What is your assumed baseline?

100 hp
250 hp
500 hp
750 hp
1500 hp

6. What is your procedure for determining the diesel PM emission reduction potential of your technology?

7. Do you recommend a maximum fuel sulfur level for your technologies?

8. Are your retrofit technologies applicable to old engines? What are the issues that may prevent your technology from being applied to older engines?

9. How would you classify the availability of your retrofit technologies? Are the technologies available off the shelf or do you employ an engine by engine approach?
    - Wisconsin's time frame is 2-3 years. Will the technology be available during this window?